An Ultra-Wideband Cryogenic Receiver for the Parkes Radio Telescope

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1. Extended Abstract

There is a continuing trend in radio astronomy to develop receiving systems with broader bandwidths. Broadband receivers allow for the possibility of higher sensitivity in the study of phenomena such as pulsars. They also have a practical advantage in that fewer receivers are needed to cover the operating band of a telescope.

Beyond bandwidths of 2:1 the development of high sensitivity receivers presents several challenges. Wideband feed horns typically suffer from poorer spillover and aperture efficiencies. Beam symmetry and cross polar performance are also typically degraded. Low noise amplifiers (LNAs) with noise figures equal to their narrow band counterparts are difficult to produce and these LNAs must be highly linear in order to avoid second order interference products. In narrow band systems these second order products may be filtered out.

We present the design and measured performance of a wideband cryogenically cooled receiver operating over a frequency range of 700-4200 MHz (a bandwidth of 6:1). The feed horn is a dual polarized quad-ridged feed horn with a central dielectric insert. The addition of the dielectric insert enables a constant beam width over the band. The dielectric insert contains a central portion made of fused quartz and an outer portion made of PTFE.

A significant challenge in the development of a cryogenic LNA covering the 6:1 bandwidth is achieving a low noise figure while maintaining a high return loss. The LNA of the present design employs an active feedback network which allows a wideband match to be achieved with only a small penalty in noise figure. The LNA contains two stages of amplification in the primary signal path and a further two stages of amplification in the active feedback network.

In order to reduce the thermal noise due to losses in the feed horn, the ridged section of the feed including the dielectric insert is cooled to approximately 100K. The high coefficient of thermal expansion of the PTFE dielectric outer section results in a difference in the thermal contraction of the PTFE relative to the aluminium ridges and the quartz inner dielectric. Finite element analysis has been employed to determine the extent of this effect and geometrical adaptations are implemented to accommodate it. A model of the receiver is presented in Figure 1.

A prototype room temperature feed was reported on previously [1]. Here we present a system description, detailing the construction of the system and in particular the cryogenic aspects of the system. We present the system noise temperature, examine the various contributions to the system noise and compare these with a narrow band system.

2. References


Figure 1. A cross sectioned model of the receiver. The quartz section is displayed in red, the PTFE section in green and the vacuum window in light blue.